NEWSLINE

Published weekly for employees of Lawrence Livermore National Laboratory *Friday, February 21, 2003* *Vol. 28, No. 7*

FROM THE DIRECTOR'S OFFICE

TOMAS DIAZ DE LA RUBIA

Simultaneous excellence in S&T and operations

Director's note: Senior management recently unveiled a set of values for the Laboratory. Each value will be discussed in a Director's Office column. Today, Tomas Diaz de la Rubia, AD for Chemistry and Materials Science, looks at the third value — simultaneous excellence in science and technology, operations and business practices.

Since the Laboratory's founding in 1952, our goal has been to strengthen the security and well-being of the nation by applying the very best science and technology within an environment that integrates safety, security and sound business practices. To fulfill that goal we follow the same strategy pioneered by E. O. Lawrence: form multidisciplinary teams of scientists, engineers, safety and security experts, and business specialists who work together to accomplish our mission.

As we have often heard from our senior managers, "Ours is still Lawrence's laboratory." Our ability to do things as tightly integrated teams is embedded in the very fabric of our institution. To be successful, we must always strive for simultaneous excellence in science and technology, operations and business practices. When this partnership is fully realized, i.e., when we all share the same goals and work together, the Laboratory is at its best in solving the problems that the country has entrusted to us.

Teamwork and a relentless drive for excellence have assured our continuing success as a national — and internationally — acclaimed resource of applied science and technology.

Excellence in science and technology keeps the Laboratory vibrant, creative and responsive to new national challenges. At the same time, working safely is essential to meeting our mission, and our safety record is superior and getting better. Similarly, security is also one of the most important considerations in our daily work. Protecting classified and sensitive information, nuclear materials, and other valuable assets is critically important.

In addition, as Steve Hunt discussed in

See **DIRECTOR'S OFFICE,** *page 4*

New performance management system

Director Michael Anastasio today unveiled a modified performance management system and updated employees on various Survey Action Team commitments.

The Integrated Performance and Pay Program is one of the most anticipated action items resulting from the Employee Survey taken almost two years ago. "The program, endorsed by senior managers at last week's off-site, is designed to be more consistent and less complex than previous performance management approaches. It also emphasizes management accountability," Anastasio said. "This is a significant step in answering employees' requests while meeting the needs of management to successfully assess and reward employee contributions."

While some details of the performance and pay program are still being finalized, Anastasio rolled out key components, emphasizing the system will bring more uniformity and consistency. Yet it will also provide flexibility to handle "compelling business needs." Employees will receive details of the program within the next few weeks and will have 30 days to submit comments; it will be implemented in time for this year's performance appraisal process.

The Integrated Performance and Pay Program is based in part on benchmarking at other major R&D labs and private sector companies, and in-

See **SAT,** *page 3*

Staged approach to Yucca Mountain discussed

By Anne M. Stark
NEWSLINE STAFF WRITER

DENVER, Colo. — Livermore scientist Tom Issacs, who is also a member of the National Academy of Sciences' National Research Council gave a progress report on the Yucca Mountain nuclear waste repository at the 2003 meeting of the American Association for the Advancement of Science held this week.

Tom Issacs

Isaacs, a Livermore physicist and one of the 14 members of the National Research Council, discussed the unique societal, scientific and technical demands that face federal officials working to store high-level radioactive waste at Yucca Mountain, which sits 100 miles northwest of Las Vegas.

He spoke Tuesday during the session titled: "Nuclear Waste: File and Forget?" The 201-page NRC report, "One Step at a Time," outlines a staged development concept for the repository planned at Yucca Mountain.

"Building the underground and surface repository facilities in stages would allow decisions to be based on the latest available information," the report states. "The sooner the Department of Energy adopts adaptive staging for Yucca, the more effective this approach is likely to be."

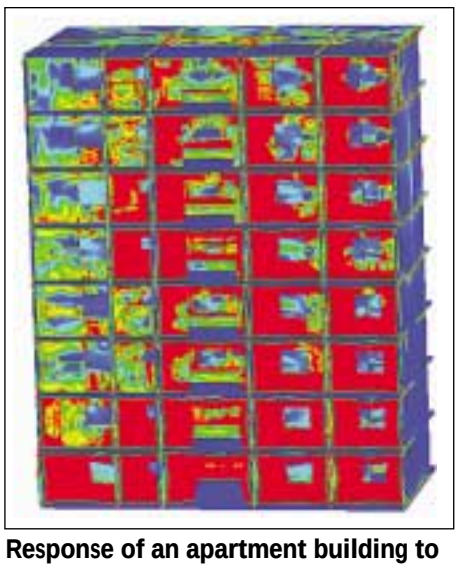
See **YUCCA** *page 4*

Simulation strengthens defense against terror

By Anne M. Stark
NEWSLINE STAFF WRITER

DENVER, Colo. — Using advanced computing capabilities, Lab engineer Bob Ferencz of the Engineering Directorate illustrated on Sunday some of the issues that arise when mitigating the effects of bomb blast on infrastructure.

His presentation was one of seven given during a security technology session at the 2003 annual meeting of the American Association for the Advancement of Science.



Response of an apartment building to blast loading using Mechanical Engineering's ParaDyn code. Areas of red indicate high damage.

Since the attacks on the World Trade Center, the Pentagon and at major U.S. embassies and military facilities abroad, the nation's bridges, buildings and dams are considered desirable targets for terrorists intent on creating maximum damage and numerous deaths.

On Sunday, Ferencz highlighted advanced computer simulations performed at LLNL and the U.S. Army Engineering Research and Development Center. Such simulations can be used to examine the performance of representative structures under blast loadings and explore design alternatives. These regimes of behavior are quite different from those associated with more typical design requirements such as an earthquake.

The simulation technologies used were originally developed within the Department of Energy's Defense Programs activities at LLNL and Sandia

See **BLAST,** *page 4*

Police chief visit

— Page 2

Black History Month celebrated

— Page 3

***Up Close** on science*

— Special Section

LAB COMMUNITY NEWS

Weekly Calendar

Technical Meeting Calendar
on page 3

Friday 21

Today is the last day to purchase tickets for the Chinese American Networking Group's (CANG) annual **Chinese New Year's luncheon.** The year of the Ram will be celebrated at the Willow Tree in Dublin on Thursday, Feb. 27 from noon to 1 p.m. Admission will be by advanced ticket purchase only. Contact Eric Chow for tickets at 2-0552 or chow6@llnl.gov. Lunch will be served promptly at noon so please plan to arrive early.

Saturday 22

There will be a **scheduled power outage** from 7 a.m. to 3 p.m. in Trailers 1713, 1714, 1730, 1735, 1884, 1885 and 1879. Contact: Mark Cardoza, 3-0490.

Tuesday 25

The **LLESA Apple Computer Networking Group** will meet at 7 p.m. in the LLNL Visitor Center Press Room. Everyone with an interest in Apple brand and compatible computers is welcome to attend. Contact: Jim Branum, 2-6766.

• • •

The LLNL **Retirees Travel Slide Group** will meet at 2 p.m. in the Livermore Library meeting room. Margo and Arne Kirkewoog will present "Adventures in New Zealand and Australia."

Thursday 27

Joseph Marshall, executive director and co-founder of the Omega Boys Club/Street Soldiers will discuss, **"The More You Know, The More You Owe,"** at noon in the Bldg. 123 auditorium. His talk is in honor of Black History Month and is sponsored by the Diversity & Work/Life Programs Office and the Association of Black Laboratory Employees. Contact: Diversity & Work/Life Programs, 2-9543.

Friday 28

The next session of the Benefits Office's brown-bag series on how to enhance your financial security by participating in the **Tax-Deferred 403(b)** will be held from 12:15-1:15 p.m. in Bldg. 571, conference room 2301; additional sessions will be held on the last Friday of each month through October. Attendance is open and no pre-registration is required. Bring your lunch and your questions. For additional information about benefit services or events, see the Website at www.llnl.gov/jobs/benefits.

• • •

A representative from **California Casualty Insurance** will be in the Benefits Office. Appointments are required and may be scheduled by calling 2-9955. California Casualty offers individual rates to Lab employees by payroll deduction for auto and homeowner/renter insurance. As with any employee-paid insurance coverage, employees are encouraged to comparison shop.

Discussing heightened security

FRANK NUNEZ/IBIS

Joe Krueger (left) and Russell Miller (right), both of Safeguards & Security, met with Livermore Police Chief Steve Krull (center) to discuss heightened security at the Laboratory during the chief's visit to the Laboratory on Feb. 6. Krull also received a briefing on homeland security from Wayne Shotts, toured the National Ignition Facility and visited the Discovery Center.

DDLS features former LANL director Agnew

The next Director's Distinguished Lecturer Series talk will be given by Harold Agnew, former director of Los Alamos National Laboratory, on March 11 at 3 p.m. in the Bldg. 123 auditorium. He will discuss how the twin paths of LLNL and Los Alamos have been intertwined since 1952.

Agnew, who served as LANL director from 1970-79, will reflect on how Livermore and Los Alamos have grown up together, how their strengths and cultures vary, and how their combined talents — and the value of peer review — have enriched the nation.

Director Michael Anastasio invites all employees to attend this talk.

Agnew's career in defense began when as a young college student, he relocated to the University of Chicago to join the Manhattan Project, working with Enrico Fermi. He was present on Dec. 2, 1942, when the first self-sustaining nuclear chain reaction was initiated and controlled.

He joined Los Alamos in 1943 to work on the atomic bomb and was aboard the plane that bombed Hiroshima. His were the only photographs of the event.

In the 1950s, Agnew was a manager at LANL when the opening of a second laboratory at Livermore was debated in Los Alamos and Washington. He took a leave of absence from Los Alamos in 1961 to become science adviser to the NATO supreme allied commander in Europe. He returned to Los Alamos in 1964, where he was named head of the Weapons Physics Division.

In 1970, he succeeded long-time Los Alamos Director Norris Bradbury. As director, Agnew focused his tenure on broadening the scope of Los Alamos, strengthening the theoretical physics program, improving computer resources and developing a better budgeting system.

He left Los Alamos in 1979 and become head of General Dynamics in San Diego.

Agnew won the E.O. Lawrence Award in 1966 and the Fermi Award in 1978.

Today, he is adjunct professor at UC San Diego and serves on the UC National Security Panel.

DOE, Labor offer assistance for ill workers

Representatives of the U.S. departments of Energy and Labor will be in the Bay Area March 3-6 to assist current and former nuclear weapons workers and their survivors who have questions or need help filing a claim under the Energy Employees Occupational Illness Program Compensation Act.

The act became effective July 31, 2001.

The Labor Department administers the program that provides a lump sum of up to $150,000 and payment of future medical expenses to current and former Energy Department employees and contractor employees who suffer from radiogenic cancers, beryllium disease and chronic silicosis. Qualified survivors of covered employees, including adult children, also are eligible for benefits.

The Energy Department program helps contractor employees apply for state worker's compensation if it is determined by an independent physician's panel that the worker sustained an illness caused by exposure to a toxic substance at an Energy Department facility.

Energy Department designated facilities include Lawrence Livermore and Lawrence Berkeley national laboratories, Sandia/California, Hexcel Products in Berkeley; Hafer Tool in Oakland; Pleasanton Tool and Manufacturing; Electrofusion and Poltech Precision in Fremont; and EDM Exotics in Hayward.

Workers who need help filling out claim forms can schedule appointments by calling toll-free 1-866-697-0841 or dropping in during hours listed below:

• 8:30 a.m. to 6 p.m. March 3-6 at Four Points Hotel by Sheraton, 5115 Hopyard Road, Pleasanton.

• 8:30 a.m. to 6 p.m. March 5 and 6 at Woodfin Suite Hotel, 5800 Shellmound St., Emeryville. Call 510-637-1818.

Newsline

Newsline is published weekly by the Internal Communications Department, Public Affairs Office, Lawrence Livermore National Laboratory (LLNL), for Laboratory employees and retirees.

Contacts:

Media & Communications manager: Lynda Seaver, 3-3103

Newsline editor: Don Johnston, 3-4902

Contributing writers: Elizabeth Campos Rajs, 4-5806; Bob Hirschfeld, 2-2379; David Schwoegler, 2-6900; Anne M. Stark, 2-9799; Stephen Wampler, 3-3107; Gordon Yano, 3-3117. For an extended list of Lab beats and contacts, see http://www.llnl.gov/llnl/06news/NewsMedia/contact.html

Designers: Denise Kellom; Julie Korhummel, 2-9709

Distribution: Mail Services at LLNL

Public Affairs Office: L-797 (Trailer 6527), LLNL, P.O. Box 808, Livermore, CA 94551-0808
Telephone: (925) 422-4599; Fax: (925) 422-9291
e-mail: newsline@llnl.gov or newsonline@llnl.gov
Web site: http://www.llnl.gov/PAO/

AROUND THE LAB

SAT

Continued from page 1

depth analyses of options. The system will utilize ranking and will reward total contribution to the Lab. "Performance will be one part of that," Anastasio said.

"We feel this is the best way to reward excellence and ensure the Laboratory has the top talent it needs to accomplish its missions," Anastasio added.

The Integrated Performance and Pay Program is designed to reinforce Laboratory Values, including:

- Rewarding and recognizing performance.
- Teamwork while preserving individual initiatives.
- Commitment to the collective success of the Laboratory.
- Preserving a high-quality workforce with diverse ideas, skills and backgrounds.

As part of this new process, standardized performance appraisal forms will be used, with one set for exempt employees, one for non-exempt and one for supervisors and managers. The performance appraisal process will provide greater emphasis on setting goals, clarify performance expectations and assessment and provide a standard feedback method.

"This process will rely on ongoing discussion and feedback, in addition to the annual review," Anastasio said.

The program establishes three common criteria: performance, job, and relevant skills, knowledge and ability to assess each employee's total contributions. In addition, the directorates will develop characteristics of each rank group. Current ranking systems will be used this year for 100, 400 and 500 series employees, with changes to those ranking systems coming next year.

The program also establishes common target salary constructs for 200s and competitive salary grades for other series within and among all directorates.

Anastasio also took time to update other actions resulting from the Employee Survey. Most work/life efforts (flexible work options, adding UPS service, converting the old Lab store to employee interest group meeting facilities) have been completed, while several others (dry cleaning services, childcare review) are nearing completion. Only the South Mall Conversion Project has been deferred.

Other completed survey action projects include the re-establishment of workforce reviews and an apprenticeship program.

Projects close to completion include an employee handbook, maintaining a competitive total rewards program and streamlining postdoc training and LDRD reviews.

"We are making steady progress on our commitments from the survey, but we have more to do," Anastasio said. "The Lab is committed to providing a high-quality, motivated workforce, with diverse ideas, skills and backgrounds. These survey action commitments will help ensure the Lab has the talent it needs to accomplish its goals."

Omega Boys co-founder to speak

In honor of Black History Month, Joseph Marshall, executive director and co-founder of Omega Boys Club/Street Soldiers, will speak at the Lab on Thursday at noon in the Bldg. 123 auditorium.

Marshall's talk "The More You Know, The More You Owe," is co-sponsored by the Diversity & Work/Life Program office and the Association of Black Laboratory Employees. It is open to all employees.

Joseph Marshall

Marshall, who grew up in South Central Los Angeles, earned his bachelor's degree at the University of San Francisco and his master's degree at San Francisco State University.

While teaching middle school in San Francisco, Marshall saw too many children drop out, go to jail or die. He teamed up with Jack Jacqua, a fellow staff member at Potrero Hill Middle School, to form the Omega Boys Club in 1987.

The organization began with 15 members and offered tutoring, basketball and other activities aimed at keeping young people alive, unharmed by violence and free from incarceration. Since then, more than 180 young people supported by the Omega Boys Club/Street Soldiers have gone to college.

Omega's services include the Omega Academic Preparation and Scholarship Program, a 36-week course to prepare youth for college; the Street Soldiers Violence Prevention Program; Omega Training Institute; and the Street Soldiers Radio Show, a nationally syndicated call-in show which provides approximately 450,000 listeners in 40 cities with weekly counseling.

Marshall earned his doctorate in psychology from Wright Institute in Berkeley in 1997. He has served as a planning board member of the Surgeon General's Report on Youth Violence and as an adviser for community violence prevention at the Harvard University School of Public health.

Honors he has received include the Freedom Works Award from Congress and a MacArthur "genius" Award.

For more information about this talk, call the Diversity & Work/Life Program office at 2-9543.

Technical Meeting Calendar

Friday 21

PHYSICS & ADVANCED TECHNOLOGIES
"A Diamagnetic Relativistic Pulse Origin of Cosmic Gamma-Ray Bursts," by Edison P. Liang, Rice University. Noon, Bldg. 319, room 205 (uncleared area). Contacts: Michael Gregg, 3-8946, or Sandra Maldonado, 3-0621.

Monday 24

ELECTRONICS ENGINEERING TECHNOLOGIES
"Incident Management in an Adversarial Environment," by John Lathrop. 10 a.m., Bldg. 235, room 1090 (uncleared area). Contact: Cathy Kenton, 4-3875.

FRONTIERS IN SCIENCE & TECHNOLOGY: QUANTUM COMPUTATION AND INFORMATION SEMINAR SERIES
"Cryptography in the Quantum Computing Era," by Claude Crépeau, McGill University. 3:30 p.m., Bldg. 543 auditorium (uncleared area). Contact: Linda Bodtker, 3-0421.

Tuesday 25

PHYSICS & ADVANCED TECHNOLOGIES
"The Production of the Ne, Na, Mg and Al Isotopes in Asymptotic Giant Branch Stars," by Amanda Karakas, Centre for Stellar and Planetary Astrophysics. Noon, Bldg. 219, room 163 (uncleared area). Contacts: David Dearborn, 2-7219, or Sandra Maldonado, 3-0621.

RADIATION DETECTION CENTER
"Geological Application of Nuclear Techniques," by Ahmed Badruzzaman, Chevron Texaco Exploration & Production Technology . 11 a.m., Bldg. 219, room 163 (uncleared area). Contact: Gregory Schmid, 3-7866, or Christie Shannon, 3-6683.

Thursday 27

UNIVERSITY RELATIONS PROGRAM
"Coherent Nonlinear Spectroscopy of Single Quantum Dots," by Gang Chen, Bell Labs/Lucent Technologies. 10 a.m., Bldg. 319, room 205 (uncleared area). Contact: Edie Rock, 4-4035.

Daffodil Days returns

Orders are now being taken for Daffodil Days, the annual fund-raiser for the American Cancer Society.

A bunch of freshly cut daffodils (10 stems) is $10; a vase is available for an additional $8.

Each spring, the Laboratory participates in this benefit for the American Cancer Society and is one of the top fund-raisers in California. Employees donated more than $20,000 in last year's campaign.

Daffodils are on sale through March 4 and will be delivered on Monday, March 24. A complete list of Daffodil Days volunteers was printed in the Feb. 14 issue of *Newsline*. For more information about the fund-raiser, contact Germaine Clark at 2-1135.

Classified ads to return in next week's Newsline

Because of the special "Up Close" insert, there are no classified ads in today's Newsline**. The classified ads will return next week. Ads for this week will need to be resubmitted in order to appear in** Newsline **prior to publication on the Web.**

https://www-ais.llnl.gov/newsline/ads

DIRECTOR'S OFFICE

Continued from page 1

this column last week, integrity and responsible stewardship of the public trust mean conducting every aspect of our work in a manner that reflects the highest ethical standards. As we conduct our operations and carry out our programmatic missions, we must strive for excellence in how we handle funds and property, how we use facilities, equipment and resources, and how we treat our workforce. We must rely on our own sense of responsibility to always do "the right thing" and be accountable for our actions.

State-of-the-art unique experimental research facilities are a core strength and we continue to make significant facility investments. Our operations in these facilities are guided by a complex set of state and federal regulatory requirements. Our ES&H teams, expert in those regulations, work with scientists and engineers to develop the processes that efficiently and effectively meet the technical objectives consistent with ES&H requirements. However, we all must take ownership of learning and carefully observing rules and regulations and making recommendations to further strengthen the work environment.

Some examples help illustrate how simultaneous excellence in S&T, operations and business practices help us meet our mission objectives.

We are making significant progress toward completion of the National Ignition Facility, which will be a cornerstone of the nation's Stockpile Stewardship Program, and a scientific resource for the country. The fact that safety is a shared commitment for all of us is best exemplified by the fact that workers at the National Ignition Facility have achieved more than 2.7 million hours without a workday lost to injury. For the next 25 years, in addition to its key role in national security, cutting edge science on NIF will undoubtedly lead to exciting new discoveries in fields as disparate as astrophysics and materials science.

We value

Passion for Mission

Integrity and responsible stewardship of the public trust

Simultaneous excellence in science & technology, operations, and business practices

Balancing innovation with disciplined execution

Teamwork while preserving individual initiative

Intense competition of ideas with respect for individuals

Treating each other with dignity

A high-quality, motivated workforce with diverse ideas, skills, and backgrounds

Rewarding and recognizing performance

Commitment to the collective success of the Laboratory

Construction is also well along for the Terascale Simulation Facility (TSF), and contracts have been awarded to the winning bidder to build the next generation of Advanced Simulation and Computing (ASCI) computer systems for the Laboratory. When complete, the TSF computers will provide an unprecedented 460 teraops of computer power for both classified and unclassified research. These resources will once more position Livermore as the largest supercomputing center on the planet. But more importantly, the TSF will enable us to fulfill our mission and deliver on our commitments to the country, and to explore the frontiers of science.

Our stockpile stewardship mission often places stringent demands on the partnership between our scientists and our operations experts. Recently, Livermore scientists were able to determine the density and size of small bubbles in aged plutonium through state of the art electron microscopy experiments — a critical result for assessing the lifetime of Pu pits in the stockpile. It was through the teaming of scientists, program leaders and safety experts that we were able to conduct these critical experiments in a laboratory setting while utilizing multi-purpose research instruments that continue to be available for myriad other applications. Without careful planning by an integrated team, these experiments could never have taken place and our ability to meet our mission objectives would have been compromised.

Sustaining our science and technology base also means investing in our staff. Our scientific and technical success is dependent upon an outstanding workforce. We must continue to attract and retain the best and brightest, including those from other nations.

A major factor in attracting top talent is our strong bond with the University of California. The UC contract nurtures a culture that values excellence in science and technology as well as independent viewpoints and research integrity. We benefit from our association with UC through myriad collaborations with faculty and staff at the UC campuses. Many UC students carry out their graduate research at the Laboratory and often become Livermore employees later in their careers.

Providing for national security through excellence in science and technology is Lawrence Livermore's defining mission. We are Lawrence's Lab. I have personally witnessed the accomplishments that can come from simultaneous excellence in science, technology, operations and businesses practices vital to the nation's future. It is a value that has never been more important for the continuing success of the Laboratory than it is today.

BLAST

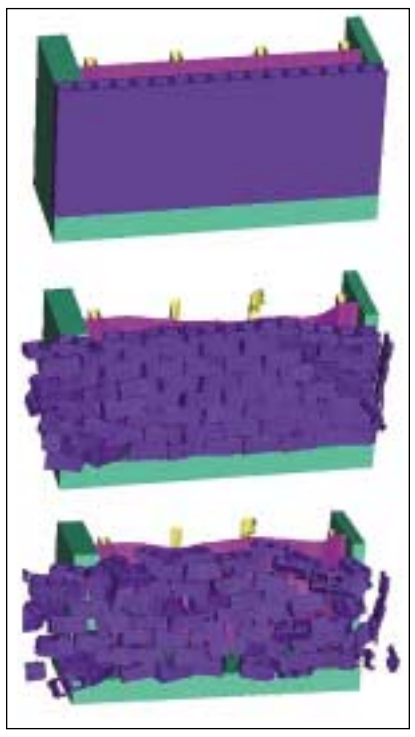
Continued from page 1

National Laboratories. Some of these technologies have already found wide acceptance in non-defense uses, such as for crash safety simulation in the automotive industry.

Ferencz, who participated in the AAAS session titled "Security for Life: The Science Behind Security Technologies," noted that blast resistance already is a design criteria for some critical structures.

Ferencz discussed a project that Livermore is working on with UC Berkeley in which engineers are trying to prevent buildings from progressive collapse similar to what happened after the blast at the Murrah Federal Building in Oklahoma City.

Engineers are working on mitigation strategies for existing and new buildings so that in case of a blast near a building, there are fewer building occupant injuries and the building is safe from collapse long enough so that search and rescue teams can enter and get trapped occupants out, he said.



ParaDyn simulation of blast response of block wall reinforced with textile liner performed by U.S. Army ERDC.

Engineer David McCallen of Livermore's Laser Science Engineering division and colleagues have constructed computer simulations to show what could happen to buildings and dams if someone used conventional explosives. Ferencz of the Laboratory's Defense Technologies Engineering division represents the Methods Development Group that created the ParaDyn, Dyna3D and Nike3D structural mechanics codes used in these studies.

"Addressing these technology areas will require research efforts in both component and full-scale experimental testing complemented by computer simulations," McCallen said. "We can now computationally model the complex nonlinear res ponse of structures up to collapse levels."

Ferencz and McCallen are interested in how to distribute these capabilities more broadly across our infrastructure. Ferencz discussed three principal areas:

- The complexity of simulating the interaction of a blast wave with a specific type of structure, which crosscuts both physics and engineering disciplines.
- Development of effective blast resistant designs for new critical structures that may require engineers to think about structural designs in new ways for this unique loading case.
- Development of retrofit methodologies for increasing the blast resistance of existing structures. Advanced computer simulations can play a key role in homeland security when the understanding gained from combined simulations and field test experiments is used to develop improved blast-resistant design guidance for the broader community of structural engineers.

YUCCA

Continued from page 1

"Adaptive staging" would avoid a rigid timeline for depositing waste at Yucca Mountain and allows project managers the flexibility to make adjustments during the disposal process based on operational experience or scientific advances.

"We think that this will assure the public that DOE is doing everything in its power to make sure the facility is safe," Isaacs said. "Using a 'lessons learned' approach during the early stages means those lessons can be incorporated into later stages."

The science board also recommends that DOE follow through on a pilot stage, after licensing from the state, which would place small amounts of radioactive waste in the repository to study performance over several years before storing large amounts of waste at the site.

DOE set 2010 as Yucca Mountain's opening date, which won congressional approval last year.

Isaacs said Yucca Mountain should have an independent scientific oversight group and stakeholder advisory board supervising the process of waste transportation and storage at the site.

NON-PROFIT ORG.
U.S. POSTAGE
PAID
LIVERMORE, CA
PERMIT NO. 154

Newsline
UC-LLNL
PO Box 808, L-797
Livermore, CA 94551-0808

• NEWSLINE SPECIAL INSERT •

Up Close on science

A monthly insert on special topics at Lawrence Livermore National Laboratory. This month: the Stockpile Stewardship Program. • • • February 2003

Focus On Stockpile Stewardship

– Bruce Goodwin

Stockpile Stewardship has come a long way

In the next year we will celebrate the 10th anniversary of one of the great scientific endeavors of our time — the effort to ensure the safety and reliability of the nation's nuclear deterrent without underground testing, formally known as science-based Stockpile Stewardship. The grand scientific challenge of the program is to assure that the nation's nuclear stockpile remains safe and reliable long past its design life through surrogate experiments and computer simulations of unparalleled fidelity.

This special section provides an overview of stockpile stewardship and some of the principal elements that make up this multi-faceted program — computer simulation, hydrotesting, subcritical experiments and refurbishment.

Stockpile stewardship has come a long way over the last decade. It's an effort that has brought out the best in the Laboratory, which has always excelled in big science and engineering challenges requiring a multi-disciplined approach. Vic Reis, former DOE assistant secretary and principal architect of stockpile stewardship, once said that certifying the safety and reliability of a weapon without testing "may be more challenging than creating the nuclear

FOCUS, See page 8

Getting 'Up Close' with science

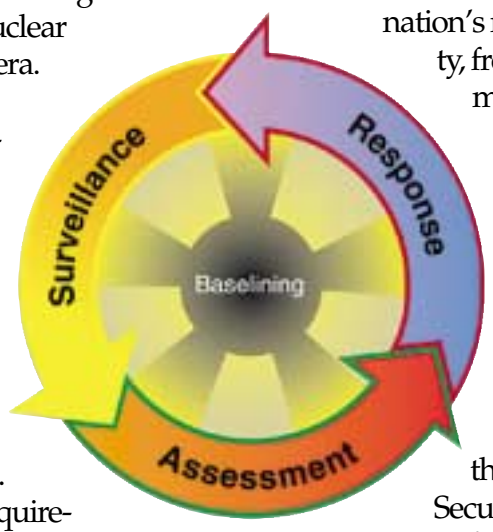
Editor's note: *Ensuring the safety, security and reliability of the nation's nuclear deterrent remains one of the Laboratory's primary national security missions. This special "Up Close" section of Newsline, spotlighting the Laboratory's stockpile stewardship activities, is the first in a monthly series featuring LLNL programs. Upcoming special sections will focus on the National Ignition Facility (NIF), genomics and bioscience, innovative science, environmental research as well as other programs.* ◆

Assessing the stockpile

As the 10th anniversary of the Stockpile Stewardship Program approaches, the annual process for assessing the status of the nation's stockpile of nuclear weapons has entered a new era.

This process, formally known as "Annual Certification," is now codified into law under terms of the fiscal year 2003 National Defense Authorization Act, signed by President Bush in December 2002. The act has placed detailed legal requirements on the Annual Certification process.

"Putting the reporting requirements into law formalizes the process and demonstrates the importance that the government places on Annual Certification," said Bruce Goodwin, associate director for Defense and Nuclear Technologies. "It shows how far we've come since Annual Certification began in 1996. Annual Certification has become the main 'report card' for the stockpile and its stewardship."



The Annual Certification process plays a central role in ensuring that everyone in the nation's nuclear weapons community, from top to bottom, has a common understanding of the health of the stockpile. This understanding is based on thorough technical evaluations by staff at the Livermore, Los Alamos, and Sandia national laboratories. Several other agencies and groups also play important roles, including the joint National Nuclear Security Administration/Department of Defense project officers groups and the Stockpile Assessment Team, an advisory panel for the United States Strategic Command (STRATCOM).

In the new process, summaries of the Annual Certification results are reported to the

CERTIFY, See page 6

A brief history of Stockpile Stewardship

In 1995, President Clinton announced that the nation would begin a program called Stockpile Stewardship. This program would use science-based methods to assess the safety and reliability of the nation's nuclear stockpile in the absence of nuclear testing. The president also called for a new Annual Certification procedure as a formal way to periodically assess and report the status of the stockpile under the new program.

"I am today directing the establishment of a new annual reporting and certification requirement that will ensure that our nuclear weapons remain safe and reliable under a comprehensive test ban," President Clinton declared. Under this arrangement, the secretaries of Defense and Energy receive annual formal assessments from directors of the three weapons laboratories — Livermore, Los Alamos, and Sandia — the commander-in-chief of the U.S. Strategic Command, and the Nuclear Weapons Council.

S&TR

A test launch of the Peacekeeper ICBM, which is equipped to carry the W87 warhead.

Some experts have compared the challenges of stockpile stewardship to the World War II Manhattan Project to develop the atomic bomb or the Apollo program to safely land a man on the moon. The reason, in part, is that nuclear weapons are extremely complex devices. Many factors greatly influence the performance of thousands of components in ways that are not fully understood. Livermore's stockpile stewardship work involves researchers from the Defense and Nuclear Technologies, Engineering, National Ignition Facility Programs, Chemistry and Materials

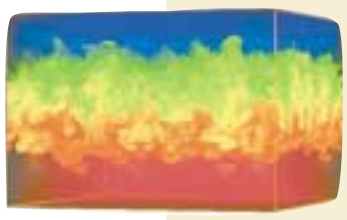
BEGINNINGS, See page 8

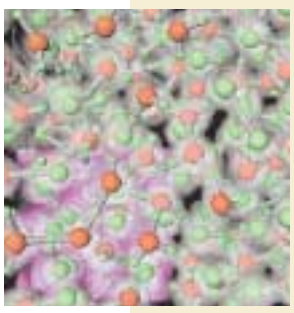
Up close: ASCI

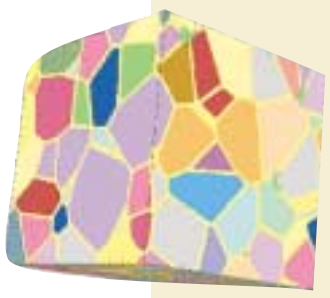
Forging new frontiers in computing

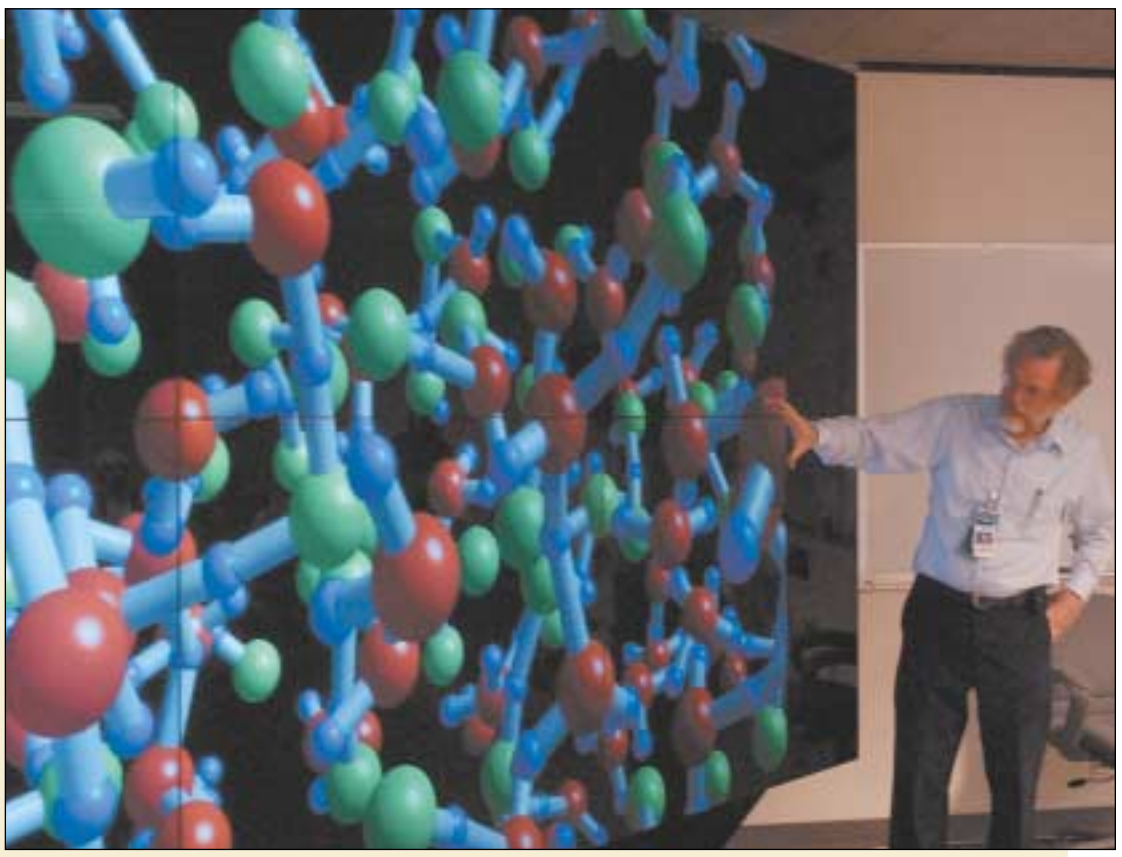
Advanced computer simulations of nuclear weapons performance are a cornerstone of the DOE/National Nuclear Security Administration's program to ensure the safety, security and reliability of the nation's nuclear deterrent without conducting underground tests in the Nevada desert.

What began as DOE's multi-lab Accelerated Strategic Computing Initiative, or ASCI, in 1995 has evolved into today's Advanced Simulation and Computing program, which has produced five of the world's most powerful computers listed in the Top500, the highly respected supercomputing benchmark organization. In the effort to produce ever-better simulations, ASCI also has enlisted some of the best computational minds in academia through its university alliances.









Julie Korhummel/Newsline

Tom Adams, above, describes an ASCI simulation during the Lab's 50th Anniversary Community Day tour. Upper left: turbulence processes shown in strongly compressible three-dimensional hydrodynamic flows. Center: quantum-level simulation of hydrogen fluoride. Bottom: high-explosive simulations in ASCI reveal the role of defects.

A goal of the ASCI program is to produce computers able to perform at 100 trillion operations per second (teraOPS), enough power to conduct detailed, or "high-fidelity," three-dimensional simulations of nuclear weapons performance. Computer models are constructed using data from past tests as well as surrogate experiments such as the subcritical materials tests at the Nevada Test Site and the thermonuclear fusion experiments to be conducted in the National Ignition Facility *(see accompanying articles, pages 4 and 5)*.

By way of comparison, one teraOP (a trillion floating operations per second) represents the processing power of 10,000 desktop computers. For instance, the 12.5-teraOPS ASCI White system at LLNL has the storage capacity of approximately 16,000 times that of a desktop computer with a 10-GB hard drive and could store the equivalent of 300,000,000 books — six times the holdings of the Library of Congress.

In a major milestone for the Stockpile Stewardship Program in December 2001, scientists at Livermore and Los Alamos national labs successfully completed two of the largest computer simulations ever attempted, the first full-system three-dimensional simulations of a nuclear weapon explosion. Each simulation took about four months of around-the-clock computing to complete.

Both simulations were conducted on Livermore's 12.5 teraOPS ASCI White supercomputer, one of the world's two fastest computers. Being able to simulate a complete weapon system allows national laboratory researchers to examine key physics issues through a combination of simulation, precision experiments, and analysis of data from past nuclear tests. Understanding these physics issues is crucial to the manufacture of replacement weapon components and the refurbishment of stockpile weapons as they age well beyond their intended life.

However, to conduct three-dimensional simulations with enough high fidelity to accurately predict the behavior of aging nuclear weapons and ensure the safety and reliability of the nation's nuclear deterrent will require processing power of even greater magnitude than ASCI White.

Last November, Energy Secretary Spencer Abraham announced a new $290 million contract with IBM to build two new supercomputers to be housed at Livermore — ASCI Purple and BlueGene/L. The two systems will have more than one-and-a-half times the combined processing power of all 500 machines currently listed in the Top500. Delivery of the Purple machine, which will serve as the primary supercomputer for the tri-lab Stockpile Stewardship Program, is scheduled for December 2004.

IBM and LLNL have collaborated on two previous generations of ASCI supercomputers — the 3.4 teraOPS ASCI Blue Pacific and 12.5-teraOPS ASCI White machines. Ever since it was founded in 1952, the Laboratory has been a pioneer of high-performance computing for scientific research.

The advent of teraOPS high-performance computing has transformed the role computers play in research and development not only in weapons physics, but across all disciplines including the biosciences and chemistry and materials science.

At the dedication ceremony for ASCI Blue Pacific in October 1999, Computation Deputy Director and current Acting ASCI Program Leader Michel McCoy said the supercomputer was ushering in "a new era of scientific computing as revolutionary as any scientific development in the last century.

"We are celebrating doing science in a way it has never been done before," McCoy continued. "We are taking the first step that will establish simulation as an equal partner to theory and experiment." ◆

Up close: Site 300

Hydrotesting is of primary importance

Explosives testing experiments have resumed in the recently completed Contained Firing Facility at the Laboratory's Site 300 experimental test site on Corral Hollow Road in the Altamont hills.

The Contained Firing Facility, or CFF, houses one of the world's most modern and resilient indoor explosives testing chambers. An experimental facility for conducting non-nuclear explosives tests indoors, the CFF is "an essential tool" of science-based stockpile stewardship. Test data will help validate codes used to model and conduct the computer simulations of nuclear weapons performance that replace full-scale testing in the Nevada desert. "With the loss of nuclear testing, the hydrodynamic testing to be conducted at CFF is an essential tool for maintaining the safety and reliability of the weapons remaining in the nuclear stockpile as they age beyond their intended life," said Lloyd Multhauf of B Division. "Hydrotests are used to assess the performance of 'primary' components in stockpile weapons."

An inside view of the Contained Firing Facility chamber at Site 300.

The 'primary' chemical explosive is what provides the initial force needed to drive a nuclear weapon's fissionable material to criticality, triggering a nuclear blast. "Hydrotesting" consists of using non-nuclear materials to produce pressures so high that solid materials flow like liquids. World-class diagnostics, such as flash X-ray radiography (FXR), allow scientists to "see inside an imploding assembly" and capture on film the dynamics of material in motion at ultra-high speeds. "The new test facility ensures the continued availability of FXR, which is today a premier single-axis radiography machine in the world for diagnosing the performance of primaries," Multhauf said.

Other state-of-the art diagnostics include a multi-beam laser velocimeter for recording the velocity of imploding metal surfaces; electron-pin diagnostics to measure the position of these surfaces; a laser-illuminated image converter camera and high-speed optics to capture detailed images of implosions, and a gamma ray camera for better X-ray detection.

"It's important to understand that most of the data for the computer codes that are used to simulate weapons performance comes from hydrotests," Multhauf said, adding that these tests also help scientists to understand better the physics of primary explosions. "Computer calculations aren't worth much if you don't have the physics right."

"This fully contained test facility provides improved environmental controls, waste minimization and safety, as well as allowing greater operational flexibility in conducting explosives tests," he added. Previously, tests were conducted on a specially constructed outdoor firing table at Bldg. 801.

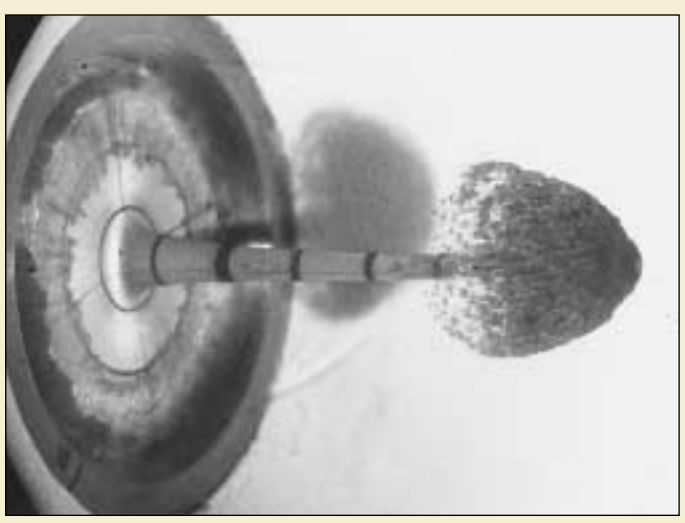
The facility was shut down for two years to allow construction of the 2,685-square-meter (28,900-square-foot) explosives test facility. The centerpiece of the new facility is the containment chamber built to replace the open-air firing table. Measuring 15.5 (51 ft.) by 16.8 meters (55 ft.) and 9.2 meters (30 ft.) high, the firing chamber is designed to contain blast overpressure and fragment effects from detonations of up to 60 kilograms (132 pounds) of PBX explosives.

Structural elements of the chamber are designed to remain elastic to permit repetitive firing. The thick walls are protected on the inside by 38-millimeter-thick mild steel able to withstand shrapnel traveling as fast as 1.5 kilometers (5,000 feet) per second.

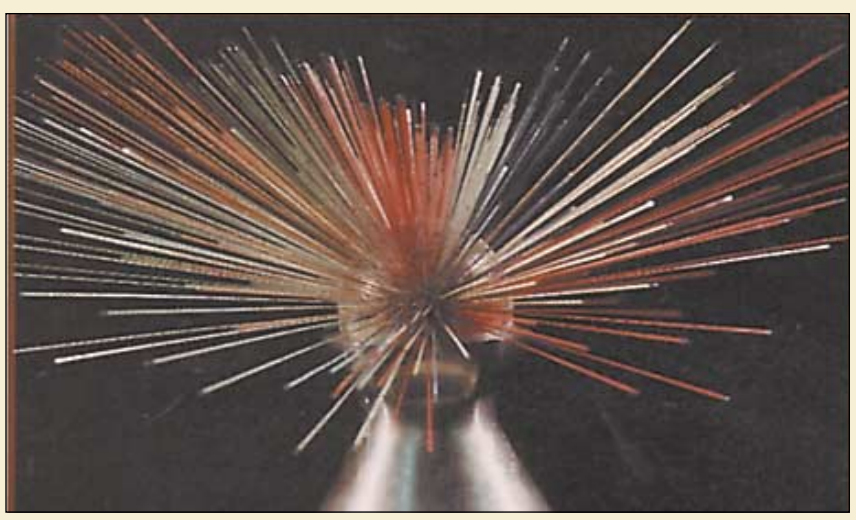
Other elements of CFF include: a 1,542-square-meter (16,600-square-foot) support area for preparing the non-explosive components of an experiment, equipment storage and personnel conveniences; a 576-square-meter (6,200-square-foot) diagnostic equipment facility; and an office module.

"CFF is designed to allow for the evolution of diagnostic technology," Multhauf said.

The facility will also be used for experiments meant to give scientists a better understanding of the physics of conventional explosives and for developing ways to defeat terrorist weapons. ◆



S&TR



S&TR

A shaped charge (left photo) speeds to the right at 8 kilometers per second during a hydrodynamic test, which illustrates the fluid-like behavior of metals when they are subjected to extremely high pressures. The fiber optic "pins" (right photo) on this pin dome receive velocity and symmetry information while a test device implodes.

Up close: NIF

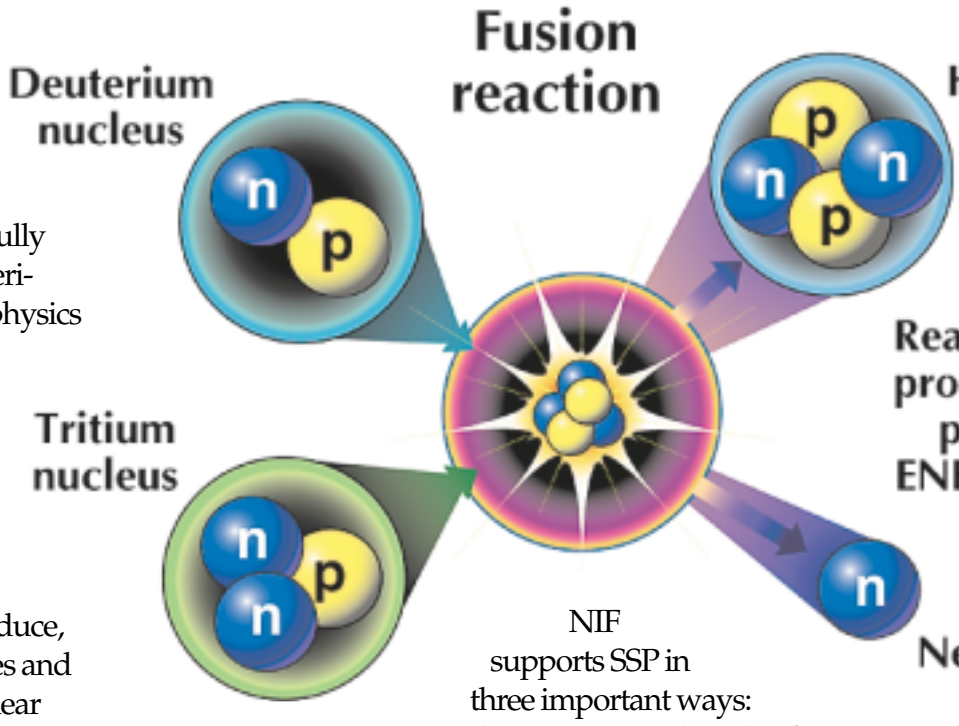
Laser beams fusion into the future

The National Ignition Facility at Lawrence Livermore National Laboratory is a key component in the Stockpile Stewardship Program (SSP). Containing the world's largest laser system, NIF will be the only facility in the SSP capable of the experimental study of thermonuclear burn in the laboratory.

Even before NIF is fully operational in 2008, its experiments will investigate the physics associated with weapons effects, radiation transport, secondary performance, ignition and output.

By focusing its 192 laser beams on a BB-sized hydrogen target, it will produce, on a tiny scale, temperatures and pressures that occur in nuclear weapons explosions, helping scientists better understand the changes that may result from the aging of the weapons' components, or from rebuilding them using new manufacturing techniques. NIF data will also help verify computer simulations of weapon performance and reliability.

"NIF will complement testing at other facilities (hydrotests, pulsed power, and advanced radiography) by extending the ability of those experiments to investigate important areas of high-energy-density science directly related to the primaries and secondaries of nuclear weapons," according to George H. Miller, associate director for NIF Programs.



NIF supports SSP in three important ways:

1) The experimental study of issues that can affect an aging or refurbished stockpile.

2) Advancing critical elements of the underlying science of nuclear weapons that will play an important role in validation of the advanced computer simulation codes.

3) Attract and train the exceptional scientific and technical talent required to sustain the SSP over the long term.

NIF can provide high quality scientific data in regimes important to weapons operations and performance, which until now, could not be reached in a laboratory. NIF data will also help answer questions raised by planned and proposed Life Extension Programs (LEPs) — the programs of ensuring nuclear weapons remain reliable, and perform their military functions well beyond their originally intended lifetimes.

Research will include the investigation of matter under conditions of extreme temperature and pressure, approaching those found in nuclear explosions and the sun. Although no present or anticipated facility can achieve the exact conditions encountered in nuclear weapons, NIF can provide a significant amount of scaling between laboratory and weapons conditions.

"The closer we can get to actual weapons conditions, the less extrapolation is required, and the greater our confidence in our understanding of weapons phenomena," said Charlie McMillan, leader of B Division, one of the Lab's two nuclear weapons design divisions.

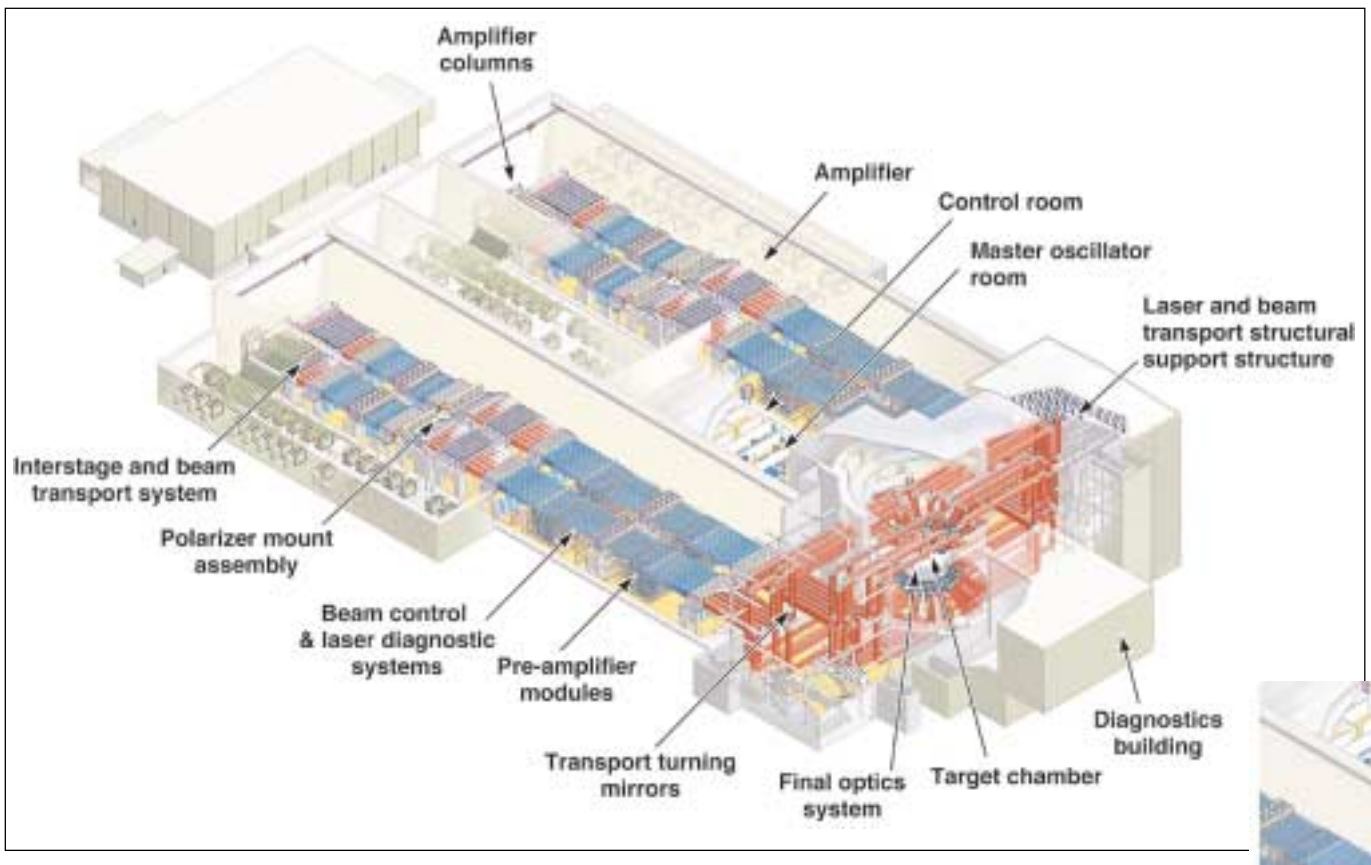
NIF will get us closer than ever before in such areas as "opacities," which govern the absorption and transmission of X-rays in a nuclear explosive device, and implosion physics.

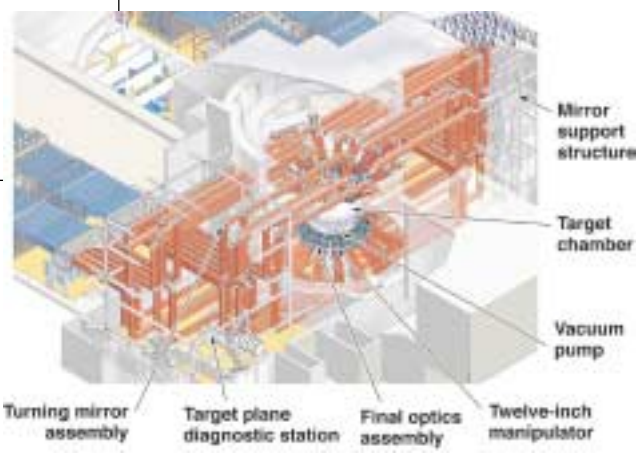
Additional materials studies must have sufficient pressure and temperature that can only be achieved after NIF begins operations with 48—96 of its beams. Still other experiments will require the full energy of NIF's 192 beams.

One final related benefit is NIF's role in fusion ignition, a significant challenge that will attract a new generation of the best and brightest scientists to SSP.

Although NIF ignition experiments will not test all of the phenomena critical for the success of nuclear weapons, they will provide a stringent test of the understanding and integration of a significant subset of these phenomena in a way that no other SSP experiments will be able to do.◆

- Bob Hirschfeld, Newsline





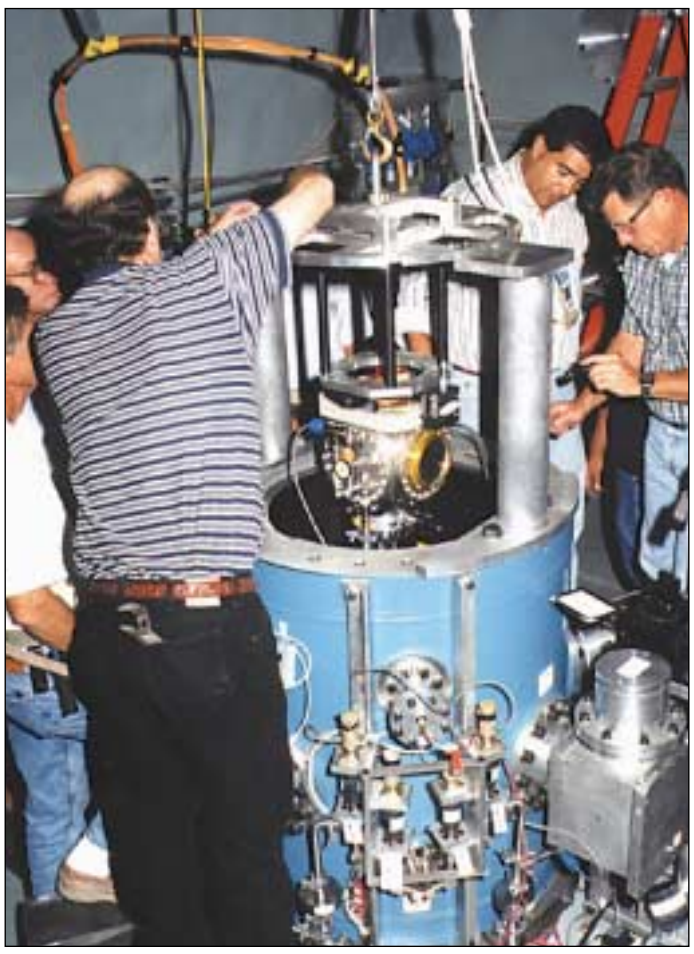
NIF

A seven-acre complex is necessary to create the incredible heat and compression that will fuse together the atoms of deuterium and tritium in a tiny target. The facility (above) consists of three interconnected buildings: Optics Assembly Building (far left), Laser Building including the target chamber (closeup diagram at right), and Diagnostics Building. The 192 laser beams will generate peak power of 500-trillion watts lasting a few billionths of a second.

Up close: NTS

Tests to understand aging of plutonium

Beneath the 1,350-square-mile Nevada Test Site — 65 miles northwest of Las Vegas — lies a complex of mined tunnels, with instrumentation rooms and experimental alcoves. Inside, Lawrence Livermore National Laboratory teams have conducted tests involving chemical high-explosives and weapons-grade plutonium-239. These are called "subcritical experiments" or "subcrits," because the amount of plutonium used is so small that it cannot reach critical conditions, and no self-sustaining nuclear fission chain reaction — like that in the detonation of a nuclear warhead — can occur.



S&TR

Livermore and Bechtel Nevada workers lower the "cube," which contains plutonium and chemical explosives, into the heavily instrumented vessel.

Shocking plutonium

Predictions about how plutonium will perform during extreme conditions require a more complete understanding of its properties. Subcrits help reveal the nature of plutonium and its alloys when shocked with high explosives. The high explosive simulates the shock that occurs when a nuclear device is detonated. The subcritical experiments reveal important information about the properties of shocked plutonium. In one type of subcritical experiment, a small disc of plutonium is shocked by a high-explosive charge, while sensitive instruments measure particles ejected from the surface.

"Although subcriticals involve both high explosives and special nuclear materials, they are, in essence, metallurgical experiments designed to learn about the physical properties of plutonium metal," said Bruce Goodwin, associate director for Defense and Nuclear Technology.

The experimental data are used to refine advanced supercomputer simulation codes that help predict performance — as well as problems — with the nation's aging nuclear stockpile. The codes reflect what is known about the material properties of warhead constituents, especially nuclear materials.

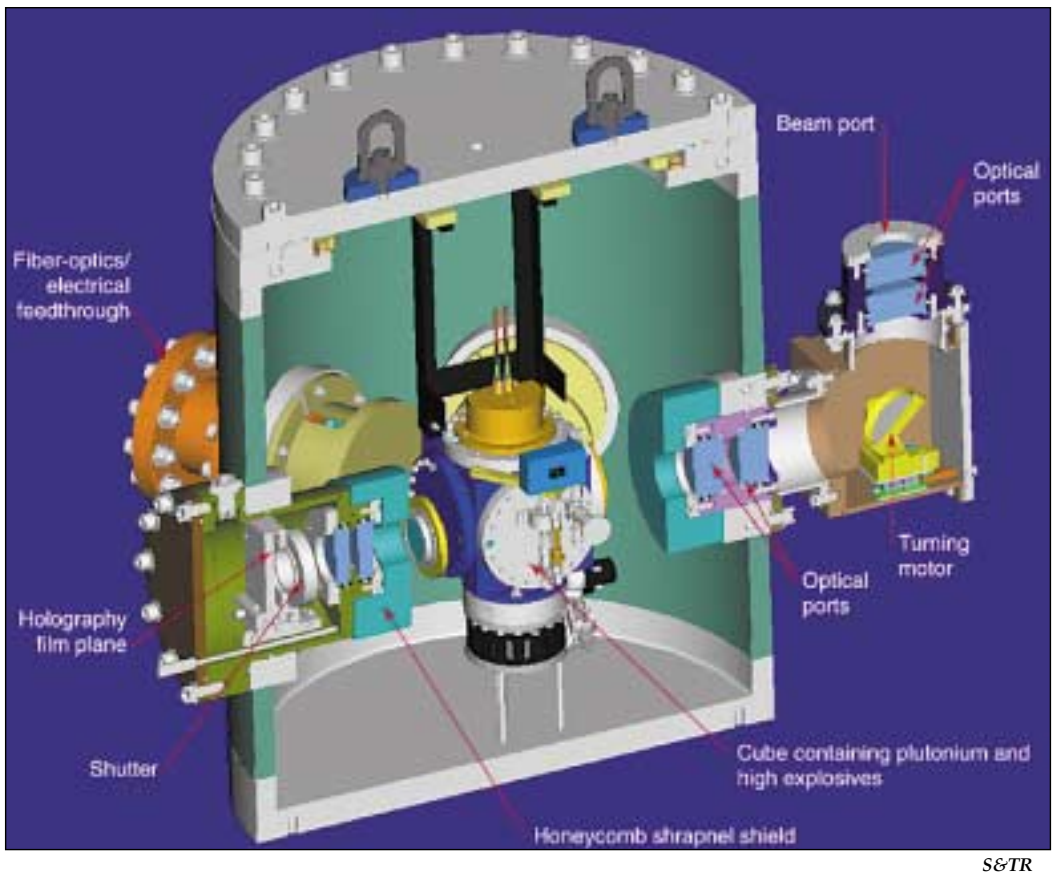
An aging arsenal

Even though current assessments indicate that weapon longevity may be successfully extended, many current stockpile weapons must be maintained far beyond their originally intended lifetimes. Assessments continue in an attempt to avoid any surprises. So there's a need to know more about how plutonium's behavior changes as it ages over several decades inside a nuclear warhead. The accumulation of alpha particles, helium nuclei, produced by the radioactive decay of plutonium atoms is thought to cause imperfections in the material's crystalline structure that could affect its performance.

To investigate the consequences of aging, subcritical tests compare the behavior of newly machined plutonium with that obtained from decades-old, dismantled warheads. The tests focus on ejecta and spall, phenomena that are thought to affect the performance of a nuclear warhead's "primary" or trigger.

Ejecta are a violent spray of plutonium particles propelled from a material's surface when it is compressed by a powerful shock wave. Depending on the shape of the shock wave, the plutonium can develop cracks in its crystalline structure or begin to break into pieces. Spall is the breakup of plutonium from the explosive shock wave.

"Subcritical experiments are happening better, faster and cheaper," said DNT's David Conrad, who was test director for several Livermore experiments. "Most Livermore subcrits have been conducted in steel cylindrical vessels that act as miniature laboratories to position instrumentation sensors and confine the explosive products in each experiment. This innovation saves considerable money and advances the test schedule, because it significantly reduces the need to mine new alcoves," Conrad explained.



S&TR

This cutaway of a steel vessel shows how laser-based imaging equipment is configured to obtain information on ejecta at the moment of detonation.

U1A complex

Subcritical tests are conducted at the Nevada Test Site's U1A complex, which consists of several buildings and instrumentation trailers where scientists monitor experiments conducted in tunnels mined nearly 1,000 feet beneath them. A mechanical hoist transports workers and equipment in the main vertical shaft, originally mined in 1968 for an underground test that was later canceled.

The complex contains several main tunnels called "drifts" and a series of small experimental alcoves branching from them. The alcoves are also called "zero rooms," from the "ground zero" jargon of the nuclear-test era. The downhole environment is surprisingly comfortable, with well-lit rooms, concrete floors, tall ceilings, and lunchrooms. This underground venue minimizes the tests' environmental impact, and costs far less than designing, building, and certifying a reusable aboveground, chamber.

Conducting subcrits at U1a also contributes to maintaining at the test site the personnel — including their unique skills and competencies — that are required to maintain presidentially mandated "test readiness," should the nation find a need to return to full-scale underground tests. ◆

—David Schwoegler, Newsline

CERTIFY

Continued from Insert, Page 1

secretary of Energy and the Nuclear Weapons Council by letters from the directors of the three national security laboratories. The commander of STRATCOM sends a similar letter to the secretary of defense and the Nuclear Weapons Council. Ultimately, the secretaries of energy and defense report in a memorandum to the president concerning the safety and reliability of the stockpile and whether a resumption of nuclear testing is needed.

"Annual Certification is a review of the status of the nuclear weapons stockpile based on the results of ongoing stockpile stewardship work," said Jim Tyler, physicist and program manager for stockpile support. Tyler, who leads the annual effort at LLNL, explains that Annual Certification provides a "snapshot" of the nation's stockpile, drawing on all aspects of the Stockpile Stewardship Program. Bruce Tarter, LLNL director during the first six Annual Certification cycles, has compared it to an annual physical.

LLNL has completed its work on the seventh Annual Certification cycle and has begun work on the eighth.

Tyler notes that a common confusion arises from the term "certification," which has a special meaning to nuclear stockpile managers. Weapons are "certified" when they are originally developed and produced or when a significant modification is made to them, and this certification doesn't expire each year. Annual Certification, however, provides a periodic assessment of the current status of the stockpile weapons and of the technical rationale for continuing their certification. "We don't recertify the stockpile warheads and bombs every year. We put together an assessment of the status of the stockpile and present it to the government," he explained.

"Under the new process, the basic technical aspects of Annual Certification will remain the same, but the process will be more formal and better documented than in the past," Tyler said, noting that the reporting requirements on the Laboratory directors are "more explicit."

The new legal requirements place a particular emphasis on the use of "red teams" in the assessment process. A charter for the LLNL Annual Certification red team has been established. The team will comprise four LLNL members and one member from each of the Sandia and Los Alamos national labs. A requirement for red team members from the other labs is one of the new legal provisions. The red team will review and, as the law says, "subject — to challenge," the Annual Certification assessment performed by the scientists and engineers who have ongoing programmatic responsibility for the various weapon systems. The charter for the LLNL red team states that it "should be particularly vigilant to look for and identify any unwarranted assumptions, technical blind spots, and inadequacies in the annual assessment and the supporting program."

S&TR

The W84 warhead, now inactive, was designed for the Ground Launched Cruise Missile, seen in this test launch.

"The idea is to provide an independent review and check on the results reported by scientists and engineers with ongoing responsibilities for the stewardship of various LLNL weapons systems," Tyler said. "Teams of experts have been used in the past to provide an independent view, but under the new Annual Certification process, the red team will be used in a more formal and rigorous way."

At the three national security laboratories, the Annual Certification process begins in January with the drafting of nine Annual Assessment Reports. The nine reports correspond to the nine nuclear weapon systems that make up the nation's nuclear stockpile *(see box below)*. Each report reviews the status of a particular warhead or bomb system. A key portion of each report discusses whether nuclear testing is needed.

Lawrence Livermore and Sandia/California staffers jointly prepare four reports, called the California reports, that describe the status of the four current nuclear weapon systems designed by their two laboratories: the W62, W84, and W87 warheads and the B83 bomb. Los Alamos and Sandia/ New Mexico experts compile the drafts of the New Mexico reports on the five stockpiled nuclear weapon systems designed at Los Alamos and Sandia.

In assembling the draft reports, LLNL managers collect and analyze information from surveillance activities as well as physics, engineering, and chemistry and materials science data from a complement of stockpile stewardship activities. These latter activities include advanced computer simulations, component-level experiments, subcritical experiments involving plutonium and high explosives at the Nevada Test Site, nonnuclear experiments at Site 300, and analysis of historical data from past nuclear tests. The reports evolve through several specified drafts and are reviewed and refined throughout the spring and summer. The final reports are published in late July.

Laboratory Director Michael Anastasio issues his Annual Certification letter in September, after the Annual Assessment Reports have been completed and published, the red team has submitted its report, and he has been thoroughly briefed on the results of the LLNL annual assessment. Among other things, his letter states whether he believes that nuclear testing is needed for LLNL-designed systems. In the past, this letter went to the secretaries of energy and defense, but under the new process, it will go to the secretary of Energy and the Nuclear Weapons Council. The Los Alamos and Sandia directors submit similar letters in September, and the commander of STRATCOM submits his Annual Certification letter to the secretary of defense and the Nuclear Weapons Council by Dec. 1.

After receiving the letters from the laboratory directors and the commander of STRATCOM, the secretaries of Energy and Defense submit the Annual Certification Memorandum to the president. In the past, this occurred at various times, but the new legal language requires this submission by March 1 of the following year. The president is required to forward this memorandum and the laboratory and STRATCOM letters to Congress by March 15. By this date, the next Annual Certification cycle will already be well underway at the laboratories.

"The legal requirements that took effect in January of this year put a stamp of value on the Annual Certification process," said Tyler, adding, "This is very new. We're still working out the details of how we're going to implement the new process." ◆

Lawrence Livermore-Designed Warheads in the U.S. Stockpile

Warhead/ Bomb Mark	Description	Carrier	Primary Use	Military Service
W62	ICBM (Intercontinental Ballistic Missile) warhead	Minuteman III ICBM	Surface to surface	Air Force
B83-0/1	Strategic bomb	B-52, B-2 bombers	Air to surface	Air Force
W87	ICBM warhead	Peacekeeper ICBM	Surface to surface	Air Force
W84 (inactive)	Cruise missile warhead	None at present (formerly Ground Launched Cruise Missile)	None at present	Air Force

Refurbishment keeps stockpile reliable

Refurbishing nuclear weapons remaining in the nation's stockpile as they age beyond their intended life is one of the key components of the Stockpile Stewardship Program.

Weapons systems that are approaching their originally anticipated duration in the stockpile are refurbished under the National Nuclear Security Administration's (NNSA) Life Extension Program. The purpose of the program is to replace any components that have limited life and to enhance the safety and reliability of the system.

In the absence of underground nuclear explosive tests, "Life Extension" involves conducting scientific experiments, engineering tests and computer simulations addressing all aspects of warhead performance.

Under an agreement concluded in 2001, the Laboratory has been working in collaboration with Sandia on refurbishing the W80 warhead — a Los Alamos-designed warhead used for the Navy's Tomahawk missile and the Air Force air-launched cruise missile. Los Alamos scientists are also involved in information sharing and peer review.

Derek Wapman of the Defense Technologies Engineering Division is leading the W80 Life Extension Program.

Divided into six distinct phases reflecting the original development steps of the warhead, the refurbishment program involves experiments at Site 300's Contained Firing Facility, LLNL's High Explosives Applications Facility, and use of the latest Advanced Simulation Computing Program (ASCI) codes — ASCI White.

"Simulation is an important part of this project," Wapman said. "As codes come to maturity, ASCI's already critical role in the life extension program will become even more important."

The three labs share surveillance data gathered through the NNSA/DOE's Stockpile Evaluation Program, in which components of a weapon, randomly selected from a system in the stockpile, are probed and tested for potential defects resulting from aging. If a part shows signs of wear or fails to perform its function, a special investigation is conducted and a decision is made as to whether remanufacturing, perhaps with some design modification, is required.

"Life extension is an enormous challenge that requires all of the expertise we have not just at this Laboratory, but all the nuclear weapons labs," Wapman said. "This is a high-powered team effort."

As other nuclear weapons systems remaining in the stockpile reach their intended life, they too may be targeted for refurbishment. ◆

Stockpile Stewardship and Management Unclassified Glossary

computational modeling
Using a computer to develop a mathematical model of a complex system or process and to provide conditions for testing it.

conventional weapon
A non-nuclear weapon.

critical mass
The amount of a radioactive material necessary to sustain a nuclear chain reaction at a constant rate.

criticality
A condition that can or does sustain a nuclear chain reaction.

dynamic test
A non-nuclear scientific experiment that shows how materials react to high-explosive shocks.

enduring stockpile
The U.S. nuclear stockpile of the foreseeable future, consisting of about seven nuclear weapon systems. No new weapon systems will be added to the U.S. stockpile during this period. Many weapons within the enduring stockpile are older than their design lifetime.

energetic material
Term that includes high explosives and propellants.

fissile material
Pu239, U233, U235 or any material containing any of these.

fission
A nuclear reaction in which a heavy nucleus is split to form two or more lighter nuclei, accompanied by the release of large amounts of energy and various forms of ionizing radiation. Fission can occur spontaneously or be induced by neutron bombardment.

flash radiography/flash X-ray
Part of hydrodynamic testing or hydrotesting that looks through the solid outer walls of an object to visualize the moving parts inside.

fusion
Nuclear reaction in which light nuclei are fused together to form a heavier nucleus, accompanied by the release of immense amounts of energy and fast neutrons.

high-explosive
An energetic material that detonates very violently, instead of burning. Examples include TNT, nitroglycerin and C-4.

hydrodynamic test or hydrotest
A non-nuclear scientific experiment that shows how materials react to high-explosives detonation. "Hydro" refers to the fluid-like flow of solids at the center of an explosion. Results are used to investigate hydrodynamic aspects of primary function during pit implosion.

ignition
Self-sustained fusion-burn of light nuclei.

implosion
Sudden inward compression and reduction in volume of fissionable material inside a nuclear weapon brought about by the detonation of conventional explosives.

limited-lifetime component
A weapon component that decays with age and must be replaced periodically.

mock nuclear material
Material that is nonradioactive and nonfissile, but similar in density and other characteristics to nuclear material. Mock nuclear material is substituted for a weapon's nuclear parts in hydrodynamic experiments and flight tests.

non-invasive imaging
Imaging methods that do not damage the test specimen, including radiography, computed tomography and other techniques.

nuclear assembly
A collective term for the primary, secondary and radiation case in a nuclear weapon. Same as "physics package."

nuclear component
A nuclear weapon part that contains fissionable or fusionable material.

nuclear reaction
A reaction in which an element's atomic nucleus is transformed into another isotope of the same element or into another element altogether. The process always is accompanied by the release of particles or energy.

nuclear warhead
A warhead that contains fissionable and fusionable material, the nuclear assembly, and the non-nuclear components packaged as a deliverable weapon.

nuclear weapons complex
The network of laboratories and fabrication plants involved in the design, production, testing, surveillance and maintenance of U.S. nuclear weapons.

numerical simulation
The use of mathematical formulas and models of physical processes to simulate through calculations, the behavior or performance of a device or complex system.

performance
Essentially equivalent to "reliability," a nuclear weapon, weapon system, or weapon component's ability to perform its required function in terms of yield, range, accuracy and radiation spectrum under stated conditions for a specified period.

physics package
A collective term for the primary, secondary and radiation case in a nuclear weapon. Same as "nuclear assembly."

pit
A nuclear weapon's central core, containing Pu239 and/or highly enriched uranium, that undergoes fission when compressed by high explosives. The pit and the high explosive are known as the nuclear weapon's "primary."

plutonium
A heavy, radioactive, metallic element, with atomic number 94, that produces ionization radiation in the form of alpha particles. Produced artificially in a reactor by bombarding uranium with neutrons, plutonium is used in the production of nuclear weapons and also can be used as fuel in fission reactors. The 15 radioactive plutonium isotopes have half-lives ranging from less than a second to thousands of years.

stockpile management
The specific tasks and functions including production, routine surveillance and servicing, assembly and dismantlement, and disposal of weapons-related parts and materials.

stockpile stewardship
The science and technology aspects of ensuring the safety, security and reliability of the stockpile, including research and development to provide technologies required for stockpile management.

stockpile surveillance
Routine and periodic examination, evaluation and testing of stockpile weapons and weapon components to ensure that they conform to performance specifications, and to identify and evaluate the effect of unexpected or age-related changes.

subcritical experiment
A dynamic scientific experiment involving special nuclear material in which none of the materials reaches criticality or involves a self-sustaining chain-reaction.

surrogate material
A material, such as tungsten, used to simulate the characteristics of actual weapons materials so tests can be conducted more cost-effectively.

test readiness
Maintaining the essential technologies, staff-skills and infrastructure to resume nuclear testing, if mandated by the president.

thermonuclear
The process by which very high temperatures are used to bring about the fusion of light nuclei — such as deuterium and tritium- with an accompanying release of energy.

uranium
A naturally occurring, heavy, metallic element. Designated atomic number 92, uranium has many radioactive isotopes. U235 is most commonly used as a fuel for nuclear fission, while U238 can be transformed into fissionable Pu239 inside a nuclear reactor.

weapons of mass destruction
Umbrella term that includes nuclear, chemical and biological weapons.

weapons-grade plutonium
Plutonium that contains less than 8 percent of Pu240.

weapons-grade
Any fissionable material in which the abundance of fissionable isotopes is high enough that the material is suitable for use in thermonuclear weapons.

yield
The force of a thermonuclear explosion, expressed in the equivalent tons of the high-explosive TNT. ◆

FOCUS

Continued from Insert, Page 1

bomb in the first place." Indeed, for the first time in history, a major scientific program is relying entirely on past experience, surrogate experiments and three-dimensional computer simulations of performance.

The program has been likened to rebuilding a fire engine piece by piece and having to guarantee it will run and operate flawlessly without ever test-driving it. Traditionally, testing permitted a top-down approach. To find out if the car worked, we took it for a test drive. Now we must ensure the safety and reliability of the stockpile without detonating nuclear devices underground. We must now try to understand the weapons and how they work from the bottom up. Weapons must be broken down into individual components and the characteristics of each piece examined to identify those areas in which we need a more detailed understanding of the physics in order to make accurate predictions about how those components will perform in different conditions over time.

This requires understanding the physics and engineering of a weapon in unprecedented detail. In addition, with older weapons systems, original parts are no longer manufactured and regulations governing their manufacture have changed, compounding the challenge for scientists and engineers. To achieve such a detailed understanding we have had to develop new scientific tools and experimental facilities for conducting surrogate experiments and computer simulations. A lot of effort in the early years of stockpile stewardship went into designing and building new tools and facilities as well as enhancing existing explosives testing facilities, notably at the Site 300 experimental test area.

The complex tasks of the stewardship program have been divided into a number of thrust areas including hydrotesting, computer simulation, manufacture, surveillance and refurbishment. These tasks have brought together a broad range of scientific and engineering disciplines including physicists, chemists, materials scientists, computer scientists and engineers with a variety of specialties.

Today, we are reaping multiple benefits from these tools, such as the supercomputers developed under the Advanced Simulation and Computing or ASCI program. Next year, the Laboratory will receive delivery of the third-generation supercomputer from IBM, ASCI Purple, a machine capable of 100 trillion operations per second (teraOPS). The advent of this computing capability benefits not only stockpile stewardship, but all of science. The development of supercomputing as a scientific tool at the national labs goes back to the founding of Livermore and has made simulation an indispensable part of the scientific process along with theory and experiment.

In December 2001, scientists at both Livermore and Los Alamos achieved major milestones when they completed the first-ever three dimensional simulations of a nuclear weapon detonation on Livermore's 12.5 teraOPS (trillion operations per second) ASCI White machine.

Other stockpile stewardship achievements include:

• The National Ignition Facility is nearing completion. Scientists and engineers have forged new frontiers in laser science and optics engineering in ways that will have many benefits to science *(see article, page 4).*

• The development of new and updated hydrotest facilities at Los Alamos and Livermore's Site 300 experimental test area. The recently completed Contained Firing Facility at Site 300 is up and running with upgraded diagnostics that make it one of the premier hydrotest facilities in the world. Los Alamos has completed the Dual Axis Radiographic Hydrotest facility or DARHT.

• Scientists have conducted a battery of tests designed to provide information about how plutonium behaves in extreme conditions. These subcritical tests conducted at the Nevada Test Site are expanding our knowledge of this most complex element and of nuclear weapons performance *(see article, page 5).*

• Scientists and engineers have advanced materials science and weapon surveillance by developing a wide range of tools and techniques for assessing the effects of aging on nuclear weapon components.

The challenge of stockpile stewardship is also helping the Laboratory continue to attract the brightest minds in science. As the weapons in the stockpile age beyond their intended life, so the challenge of stewardship becomes ever greater. We must rely on the stewards of tomorrow to continue a tradition of innovative breakthrough science to ensure the safety and reliability of the nation's nuclear deterrent into the foreseeable future. ◆

DNT

LLNL's Defense and Nuclear Technologies Directorate (DNT) is responsible for ensuring the safety, reliability, and security of the U.S. nuclear stockpile without nuclear testing, for developing advanced manufacturing and materials technologies to maintain the remaining stockpile, and for ensuring the safe dismantlement of retired LLNL weapons.

With a budget of $520 million, DNT's 1,550 employees operate the Lab's High Explosives Applications Facility (HEAF), the Superblock, and Site 300, in addition to providing overall management of LLNL activities at the Nevada Test Site. ◆

BEGINNINGS

Continued from Insert, Page 1

Science, Computation, and Physics and Advanced Technologies directorates. These researchers rely on data from past nuclear tests, past and present non-nuclear tests, fundamental science and component-level experiments, surveillance of actual weapons withdrawn from the stockpile, and advanced simulations. This approach has enabled them to successfully address stockpile issues.

Weapons of good pedigree

The weapons intended for the enduring stockpile all have good pedigrees — they went into the stockpile with blue-chip credentials. However, regular inspections of aging components have led to modifications of some weapons in the stockpile.

As with all nuclear weapons, those designed at Livermore use a wide range of materials. Changes related to aging and to interactions among materials have been observed in a number of systems and in unexpected ways, especially as systems age beyond their design lifetimes. For example, organic materials such as plastics decompose, metal joinings corrode, and many materials change properties unpredictably in response to radioactive environments.

When modifications are deemed necessary, scientists and engineers assess options for refurbishing or replacing specific components, including new production and fabrication processes and materials. Modification actions must then be formally validated. At Livermore, scientists and engineers also have broader responsibilities to develop assessment capabilities, technologies, and processes that contribute to maintaining the safety and reliability of all stockpiled weapons.

Livermore scientists use a unique collection of tools to examine and test the many materials that make up a weapon. Many of these tools were developed or modified at Livermore. For example, one tool samples gases inside a weapon's interior environment to identify potential material interactions, monitor aging indicators, and screen for defects such as incompletely cured adhesive.

Process requires special studies

One special effort for stockpile surveillance is monitoring the chemical high explosives that are detonated to implode a plutonium pit. Livermore scientists are studying the long-term stability of the complex organic molecules making up high explosives. They examine samples from the stockpile for changes in appearance and texture; measure their physical, chemical, and mechanical properties; and conduct performance tests on them.

Likewise, a focused effort is under way to better understand the aging mechanisms of plutonium pits because this understanding is crucial to predicting weapon performance. In the same vein, data from underground subcritical experiments at the Nevada Test Site contribute information on the fundamental nature of plutonium and the effects of aged plutonium.

The knowledge gained from examining nuclear weapon components and materials and their aging mechanisms is used to increase the fidelity of computer codes. Realistic computer simulations then can predict the mechanisms of material failure and reveal the likely effects of substituting different materials. ◆ *– S&TR*